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# Reexamination of Ehrenberg's Neogene Radiolarian Collections and its Impact on Taxonomic Stability

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**Abstract** All remaining Neogene polycystine radiolarian specimens which were examined by Ehrenberg were searched for in the Ehrenberg Collection, Museum für Naturkunde, Humboldt University, Berlin, Germany. Almost all the illustrated specimens in his publications were located by using published and unpublished source materials. These specimens are candidate lectotypes. However, rigid application of the International Code of Zoological Nomenclature (ICZN) would in some case causes scientifically unfruitful confusion and dispute because of very different modern accepted usage of several generic names (i.e. *Acanthosphaera*, *Cenosphaera*, *Dictyophimus* and *Pterocanium*). For these alternate type species may be required. Some illustrated specimens in publications are also broken by cracks in the embedding Canada balsam (i.e. *Podocyrtis aegles*) or are poorly preserved (i.e. *Haliomma hexagonum*) so that alternate type specimens may be required. For these reasons, we do not formally designate types in our paper, only pointing out taxonomic problems where appropriate.

**Key words:** Classification, Ehrenberg, Legacy Collection, Radiolaria, Taxonomy.

## Introduction

Description of Neogene fossil polycystine radiolarians was initiated by Ehrenberg (1839), and subsequent description of Neogene polycystines, including living ones, were actively carried out by Ehrenberg until his death in 1876 (Suzuki, 2009). Prior to 1876, only a few taxonomists described new polycystine radiolarian species (Müller, 1855a, 1855b, 1857, 1858a, 1858b; Bailey, 1856; Haeckel, 1860a, 1860a, 1862; Harting, 1863). Many species described by Ehrenberg have still been used as valid species in current papers although Ehrenberg's often simple drawings, ambiguous descriptions, and unspecified type materials are often noted as problematic by subsequent workers. The purpose of our paper is to reillustrate all polycystine specimens which Ehrenberg documented as having examined as the basis for his species descriptions, as these will presumably be used in subsequent studies to set neotypes. Additionally we document some important species for age determination of the samples, and briefly clarify points for some species. The detailed procedure how to find specimens examined by Ehrenberg himself is documented in Lazarus (1998), Lazarus and Jahn (1998) and Suzuki *et al*. (2009).

## Results

Ehrenberg (1873b) summarized the occurrences of his previously described Neogene polycystine radiolarians, and we examined all the mica strips from the localities listed in this publication that could still be found during our study. We also included material from Bermuda, Caltanisetta and Camorta, which were listed as fossil localities in Ehrenberg (1876). Neogene polycystine radiolarian specimens were found and digitally captured from the locations: Südpol (South Pole; mica tray's ID: K01B01), Camorta (Nicobar Islands; K08B10), Mexikanischer Golfstrom (Mexican Gulfstream; K16B08 and K16B09), Phillipinischer Ozean (Philippine Sea; K09B06), Oran (Algeria; K11B05), Bermuda I (K15B04), Bermuda II (K15B05), Californischer Stiller Ozean (Pacific Ocean off California; K25B07 and K25B08), Meeresgrund II ("ocean bottom sediments in the Atlantic Ocean"; K27B02), Meeresgrund I ("ocean bottom sediments in the Atlantic Ocean"; K27B03), Davisstraße I (Davis Straits; K27B17), Davisstraße II (K27B16), Caltanisetta (Sicily; K28B06), Zante (Greece; K31B07), Aegina (Greece; K31B09), Meeresgrund Mittelmeer (Mediterranean ocean bottom sediments; K32B08) and Zanguebar 13200' (MB ES 912). This last is not a mica strip but a glass slide stored with the cited Ehrenberg collection sample. Although details of the geologic ages of the examined samples will be published in a separate paper, the sea-bottom sediment samples are probably Quaternary or Holocene. These include the mica strips labeled Philippinischer Ozean, Californischer Ozean, Meersgrund I and II, Davisstraße I and II, Meeresgrund Mittelmeer, and Zanguebarica. Miocene or younger polycystines were observed samples from land section, i.e. in Caltanisetta, Zante and Aegina.

### Caltanisetta (K28B06): Plates 1 to 21

As the first illustrated fossil polycystine ever published is *Lithocampe radicula* from Caltanisetta (Ehrenberg, 1839), Caltanisetta is a sample with particular historic value for radiolarian studies. The new species found from Caltanissetta were described in Ehrenberg (1839, 1840, 1844a) and Ehrenberg (1854b). Ehrenberg (1873b) included the species names from Caltanisetta in his subsequent geographical and vertical distribution tables of recent polycystine radiolarians, although most of these species are not found in sea-bottom sediments. In his comprehensive monograph of fossil polycystines (Ehrenberg, 1876) he noted that the Caltanisetta specimens were Tertiary fossils.

Ehrenberg's mica strips are now between 140–170 years old. As noted previously (Lazarus, 1998; Lazarus and Jahn, 1998) they are brittle and sometimes were damaged due to improper storage and use in the 1970s and 1980s, as well as fire damage in the mid 1980s. The worst preserved strips encountered in this study were those from Caltanisetta. Several of the micas have become detached from their mica strips. Many of the micas are cracked, and Ehrenberg did not record the taxon name on the strip labels in the mica tray. The paper rings marking specimen locations have also partially detached from the micas. To safeguard these materials for the future, we looked through all the micas and recorded all the polycystine specimens which were encountered. Our monograph illustrates all the specimens from Caltanisetta, and thus provides a virtual copy of the radiolarian content which can largely replace further examination of this material for radiolarian studies.

*Lithocampe radicula* Ehrenberg 1839, the first illustrated fossil polycystine specimen in the history of science, is shown in this study on pl. 13, figs. 7a–7c. This form was first regarded as a foraminifera. The sketch was simple, and identifying the actual specimens required consideration of the probable inclination of the specimen used for Ehrenberg's drawing (see Suzuki *et al*., 2009). Ehrenberg's sketch (pl. 13, fig. 7c in our paper) resembles the specimen illustrated in pl. 13, figs. 8a–8b, but the former differs from the latter by the former possessing three to four longitudinal pores in a segment, and lacking a tube in the final segment. Other sketches reflect the actual specimens reasonably well: *Perichlamydium limbatum* (Ehrenberg 1844a) (pl. 8, figs. 1a–1d) and *Perichlamydium praetexta* (Ehrenberg 1844a) (pl. 8, figs. 3a–3d), for example.

Several micas could not be located in the Caltanisetta mica trays, and thus several important species were not found in our examination. *Eucyrtidium auritum* (Ehrenberg 1844a) (pl. 19, fig. 9 in our paper), for example, is missing because the indicated mica strip is missing. We can only find a single specimen (pl. 19, figs. 10a–10b) which is assignable to this species from all the remaining mica strips in Caltanisetta.

**Zante (K31B07): Plates 22 and 23**

A simple species list of polycystines from "Zante" was initially published in Ehrenberg (1839), while the new species from Zante were described in Ehrenberg (1844a) and illustrated in Ehrenberg (1854b). Zante contains a few, poorly preserved polycystines, so that we looked at all the mica strips to find and record all the polycystines as digital images; however we only found 18 specimens. *Cyrtocapsella tetrapera* Haeckel 1887 were found in the Zante material (pl. 23, figs. 1a–2b), suggesting an Early to Middle Miocene age at least. A single specimen of *Flustrella concentrica* Ehrenberg 1844a (published in pl. 20, fig. 42 of Ehrenberg (1854b) (pl. 22, figs. 3a–3c in our paper) was found.

**Aegina (K31B09): Plates 24 to 26**

New species from Aegina were described in Ehrenberg (1839, 1840, 1859), and illustrated in Ehrenberg (1854b). As with Zante, all specimens encountered in the Aegina micas were digitally recorded and are illustrated in our paper. The depositional age of Aegina is not determined yet due to lack of age-diagnostic polycystines. The first spiral polycystine probably belonging to the modern genus concept *Lithelius* was described as *Flustrella spiralis* Ehrenberg 1840, but the illustrated specimen (pl. 24, figs. 4a–4c) is not well preserved. Unpublished Ehrenberg's drawing ID 1563 illustrated "*Pterocanium graecum*" but it is a nomen nudum (pl. 24, figs. 4a–4d). *Eucyrtidium seriolatum* was formally described in Ehrenberg (1859), but has never been illustrated. We show for the first time in a publication the original drawing and photographs of the specimen in pl. 24, figs. 5a–5c.

The type species of the genus *Lithornithium* Ehrenberg 1847 was subsequently designated as *Lithocampe hirundo* Ehrenberg 1840 by Campbell (1954). The specimen of this species illustrated in our paper is shown on pl. 26, figs. 1a–1f. This species probably belongs to the modern genus concept *Lychnocanoma*, but the specimen is (originally) broken. Furthermore, Ehrenberg's concept of *Lithocampe hirundo* also included "*Pterocanium praetextum*" (pl. 26, figs. 3a–3c).

**Südpol I; 78°10′S.B. 162 W.L. (K01B01): Plates 27 and 28**

New species from the sample Südpol I were described in Ehrenberg (1844b) and illustrated in Ehrenberg (1854b). All polycystine specimens which were indicated by handwriting on the mica tray or in the Ehrenberg's drawing were searched for and illustrated in our paper. This sample is largely dominated by the genus *Antarctissa*, and other species are rare. Ehrenberg indicated the location of specimens of "*Lithobotrys denticulata* Ehrenberg 1844b" (=*Antarctissa denticulata* (Ehrenberg)) where a few specimens are indeed present within the color paper ring of the mica strip.

**Bermuda I (K15B04), Bermuda II (K15B05) and Oran (K11B05): Plate 29**

Bermuda I, II and Oran were regarded as Tertiary fossil material in the comprehensive monograph of Ehrenberg (1876). The new species from Bermuda were described in Ehrenberg (1844c, 1854b). The specimen from Oran was illustrated in Ehrenberg (1854b).

The mica trays in the Ehrenberg collection are separated into Bermuda I and II, but they are derived from a single sample, based on the handwriting on the mica tray. *Astromma entomocora* Ehrenberg 1854b (pl. 29, figs. 1a–1c in our paper) and *Pterocanium aculeatum* (Ehrenberg 1844c) (pl. 29, figs. 3a–4d) were first described from the Bermuda sample, but they have never been illustrated in the literature. *Pterocanium aculeatum* is the type species of the genus *Pterocanium*, and is apparently different from the current usage of the genus *Pterocanium* (i.e. *Pterocanium praetextum* (Ehrenberg)). A community consensus will be needed to accept, or to reject this specimen for stability of taxonomy. *Astromma entomocora* is also the type species of the genus *Astromma* by the subsequent designation of Campbell (1954), and this species belongs to the subfamily Artiscinae. *Haliomma nobile* Ehrenberg 1844c appeared to be from Barbados because Ehrenberg (1876) illustrated the form with Barbados species, but we confirmed that the illustrated specimen is actually in the mica strip Bermuda I.

A single specimen was found from Oran representing *Lithocampe lineata* Ehrenberg 1839 (pl. 29, figs. 8a–8c in our paper). An illustration of this specimen was published on pl. 21, fig. 56b in Ehrenberg (1854b).

**Meeresgrund II (K27B02): Plate 30**

Mica tray K27B02 holds mica strips from several samples. Of these, the sample "Azores Islands 6480" was the only one used for radiolarian studies by Ehrenberg. The new species from Azores Island 6480' were described in Ehrenberg (1854a) and illustrated in Ehrenberg (1854b). This sample contains the type species of *Cenosphaera*, namely *Cenosphaera plutonis* Ehrenberg 1854a (our paper: pl. 30, figs. 1a–1d). As shown in these photographs, this specimen has three concentric shells, and is probably the same as the genus *Thecosphaera*. *Flustrella subtilis* Ehrenberg 1854a was formally described by Ehrenberg (1854a), but is first illustrated in our paper on pl. 30, figs. 3a–3c.

**Meeresgrund II (K27B03): Plates 31 to 36**

This tray (K27B03) also contains micas derived from several samples. Polycystine radiolarians were examined by Ehrenberg from the samples "Atlantic Ocean 10800', Bay of Biscay" (plates 31 to 34 in our paper) and "Nord Ocean 12000" (plates 35 and 36). Many species were recorded on the labels of the mica tray, although only a few specimens were illustrated and published. All the specimens recorded on the mica trays for these two samples were searched for.

Ehrenberg (1854a) described 9 new species from the sample "Atlantic Ocean 10800' " while Ehrenberg (1854a, 1854b) described six new species from "Nord Ocean 12000'." The type species of the genus *Dictyophimus*, *Dictyophimus crisiae*, is first illustrated on pl. 35, figs. 1–1d in our paper. Several species described in Ehrenberg (1854a) have not been illustrated in any prior publications, and several of these species (*Haliomma quadruplex* on pl. 31, figs. 1a–1d; *Eucyrtidium heteroporum* on pl. 32, figs. 2a–2d; *Eucyrtidium galatheae* on pl. 35, figs. 5a–5c) appear to be different species from the modern usage of these names. Both the "Atlantic Ocean 10800' " and "Nord Ocean 12000' " samples generally yield broken polycystines (pl. 31, figs. 3a–3b), cracked specimens (pl. 31, figs. 8a–8c, pl. 32, figs. 9a–9c) and poorly preserved specimens (pl. 32, figs. 11a–11d, pl. 35, figs. 1a–1d, pl. 36, figs. 2a–2d): these specimens are probably inadequate for the designation of lectotypes or neotypes. New radiolarians slides should be made from the type materials or topotypic materials.

**Meeresgrund Mittelmeer (K32B08): Plate 37**

Ehrenberg (1854b, 1859) described seven new species from this sample. The precise skeletal morphology of *Pylosphaera mediterranea* Ehrenberg 1859 could not be determined due to a highly obliquely oriented specimen (pl. 37, figs. 2a–2d). *Eucyrtidium creticum* Ehrenberg 1859 looks very different appearance between the illustration (pl. 37, fig. 7a) and the actual specimen (pl. 37, figs. 7b–7d), but we are confident that this specimen is correctly identified as it occurs exactly where indicated by Ehrenberg- mica ring 320801.d.v.

**Camorta (K08B10): Plate 38**

Based on Ehrenberg's handwritten mica tray labels, he examined polycystine radiolarians and spherical siliceous sponge remains from the samples "Camorta XIII" (pl. 38, figs. 1a–1b, 5a–5b, 9a–11b), "Camorta XIX" (pl. 38, figs. 4a–4b, 6a–6b, 8a–8b, 12a–13b, 20a–20b), and "Camorta Nicobarien 18" (pl. 38, figs. 2a–3b, 7a–7b, 15a–16b, 19a–19b). The species names from Camorta were first published in Ehrenberg (1876), the year of his death, and four species names (*Spongodiscus argulus*, *Haliomma argulus*, *Eucyrtidium arugulus* and *Diauletes nicobarium*) are nomen nudum.

**Mexikanischer Golfstrom (K16B08 and K16B09): Plate 39**

Ehrenberg examined polycystine radiolarians and spherical siliceous sponge remains from the samples "Golfstrom 9066" (pl. 39, figs. 1a–1b, 4a–4b, 6a–9d), "Golfstrom 2556" (pl. 39, figs. 2a–2b), "Golfstrom 1158" (pl. 39, figs. 3a–3b, 5a–5b) and "Golfstrom 840" (pl. 39, figs. 10a–11d). Three new species (*Dictyocephalus pyrum* on pl. 39, figs. 9a–9d; *Rhopalodictyum truncatum* on pl. 39, figs. 10a–10b; *Dictyocephalus hispidus* on pl. 39, figs. 11a–11d) were described from Golfstrom 9066 and 840 by Ehrenberg (1862).

**Davisstraße I (K27B17): Plates 40–43 and Davisstraße II (K27B16): Plates 44–45**

New species from Davisstraße were described in Ehrenberg (1862) and illustrated in Ehrenberg (1873b). Polycystine radiolarians described from "Davisstraße " include several oceanographic marker species (e.g. *Cycladophora davisiana*, pl. 42, figs. 9a–9d; *Eucyrtidium lineatum arachneum*, pl. 44, figs. 3a–3d). These two trays hold 36 mica strips from many samples, and sample labeling is very complex. Worse, the location information of the specimens shown in the Ehrenberg's drawings is wrong for many of the mica strips in these trays in comparison with the specimens morphologically matched to them from examination of the mica contents.

Polycystine radiolarians were examined from samples recovered from water depths of 600 feet, 9240 feet (=1540 fathoms), 10998 feet (=1833 fathoms) and 11040 feet (=1840 fathoms). The sample from 9240 feet was obtained at 62°06′N, 52°21W on 18th October 1859, and that from 10998 feet at 59°12′N, 52°38W on 20th September 1859. The 9204 feet sample is further subdivided into three parts, noted by codes, namely "A.b", "B.a", "B.b", while the 10998 feet sample is subdivided into A and B. The 6000 feet sample is also subdivided into several parts, including $\beta$.II. Although we have not yet resolved the interpretation of most of these subdivided sample codes, we note that the original location ID in Ehrenberg's drawings is separately numbered for each subdivision. *Flustrella* (?) *haliomma* was described by Ehrenberg (1839), but only a single drawing of a Davisstraße specimen is available for this species. This specimen is not the original specimen for the description of *Fl*. (?) *haliomma* because the Davisstraße samples were taken only in 1859, 20 years after the original description.

**Philippinischer Ozean 19800′ (K09B06): Plates 46–57**

A total of 57 Neogene new species described by Ehrenberg were illustrated from the Philippinischer Ozean 19800' sample. The descriptions of the new species were published in Ehrenberg (1873a) and the illustrations of them were included in Ehrenberg (1873b). The published illustrations of some species (Ehrenberg, 1873b) show some ambiguous morphological characters. The drawing of *Haliomma octacanthum* Ehrenberg 1873a (pl. 48, fig. 3a in our paper) does not clearly indicate if the species is flat or spherical in shape: the photograph of this specimen clearly shows a discoidal polycystine radiolarian, probably belonging to *Heliodiscus*. It has previously been difficult to decide whether *Acanthosphaera elliptica* Ehrenberg 1873a (pl. 51, figs. 10a–10c) is a spherical siliceous sponge spicule or a polycystine radiolarian. Based on our examination, this species is a polycystine, probably related to the genus *Lithelius* or *Larcopyle*. The drawing of *Stylosphaera testudo* Ehrenberg 1873b (pl. 51, figs. 12a–12c) showed a vertical structure inside the cortical shell, but it seems to be lacking in the actual specimen. The drawing of *Stylosphaera holosphaera* Ehrenberg 1873a (pl. 53, figs. 2a–2c) was previously not regarded as belonging to this genus. The actual specimen in fact has a saturnalid ring, and is probably conspecific with *Saturnalis circularis* Haeckel 1887 under modern usage.

Owing to a thin layer of embedding Canada balsam, the morphological characters of *Stylosphaera megadictya* Ehrenberg 1873a (pl. 53, figs. 3a–3d), *Ceratospyris aculeata* Ehrenberg 1873a (pl. 53, figs. 4a–4b) and *Eucyrtidium cassis* Ehrenberg 1873a (pl. 53, figs. 6a–6c) cannot be recognized from the actual specimens. Ehrenberg created colorful drawings for several of these species as they were living specimens. *Ommatospyris penicillata* Ehrenberg 1873a (pl. 52, figs. 6a–6c), *Oms. profunda* (pl. 52, figs. 7a–7c), *Stylosphaera setosa* Ehrenberg 1873a (pl. 52, figs. 12a–12c), and *Eucyrtidium pleuracanthus* Ehrenberg 1873a (pl. 54, figs. 7a–7c) have yellowish matter within them that seems to be like protoplasmic intracapsulum, but this material appears to be aggregated clay minerals.

**Californischer Stiller Ozean (K25B07 and K25B08): Plate 58–67**

All the polycystine radiolarians which were recorded by Ehrenberg were digitally captured and are shown on Plates 58 to 67 in our paper. Ogane *et al*. (2009) pointed out that Ehrenberg erroneously mixed the location of his drawing specimens between Philippinischer Ozean 19800′ and Californischer Stiller Ozean. These two samples yield so many common species that the confusion might easily have happened. Our careful comparisons between drawings and actual specimens lead us to conclude that only eight species were illustrated from Californischer Stiller Ozean. The details of *Euchitonia furcata* Ehrenberg 1873a (pl. 60, figs. 4a–4b) were already commented in Ogane *et al*. (2009). *Ommatocampe polyarthra* Ehrenberg 1873a (pl. 63, figs. 2a–2d) seems to have a straight cylindrical form, but we cannot discriminate this species from the lateral view of three-armed discoidal species (e.g. pl. 62, figs. 4a–4c).

**Zanguebar 13200′ (MB ES 942): Plates 68–77**

Zanguebar 13200′ (database ID: MB ES 912) is also an important sample in that a total of 34 species were described and illustrated from it (Ehrenberg 1873a, 1873b). Differing from his usual mica strips, "MB ES 912" is uniquely for his radiolarian specimens, a glass slide. Ehrenberg's drawings indicate the location of the specimens and the color of the paper rings that are attached on the cover slip of the slide. However, it was impossible to locate all of the illustrated specimens only based on these indications. We therefore examined all the polycystine specimens embedded on the slide MB ES 912. It is fortunate that only one specimen was found for many species, while several broken specimens provided unique characteristics which made it possible to determine unambiguously which specimen had been illustrated by Ehrenberg. The quality of our photographs in plates 68–77 is better than any of our other plates made from mica strips because the flat glass cover slip of slide MB ES 912, mounted on the glass slide provides, like modern microscopic slides, a superior optical mount. The mounting medium is also more transparent than the uncovered Balsam present on the micas.

The drawing of *Haliphormis hexacanthus* Ehrenberg 1873a (pl. 69, figs. 1a–1d) was not useful to examine this species' internal structure. The specimen of this species illustrated by Ehrenberg does not have any internal structure, but other, unfigured specimens that we think are conspecific possess three concentric shells (pl. 69, figs. 2a–2c), suggesting assignment to the genus *Hexacontium*. *Ceratospyris pentagona* Ehrenberg 1873a (pl. 71, figs. 5a–5d) is often found in living and Quaternary samples, but the illustrated specimen is poorly preserved. We found *Acanthosphaera* (?) *fenestrata* Ehrenberg 1873a (pl. 71, figs. 8a–8c), but the classification of species to modern taxonomy was not possible because the major part of this specimen was broken off.

## Concluding Remarks

Many Neogene species that were described by Ehrenberg have been designated as the type species of genera (e.g. Campbell, 1954). The designation of Ehrenberg species as generitypes has been frequently criticized or even rejected since the quality of Ehrenberg's drawings are not always adequate and some of the species subsequently designated by Campbell (1954) were not illustrated. Our reexamination of the Neogene polycystine radiolarians in the Ehrenberg Collection has the potential to clarify the precise meaning of these generic names. On the other hand, we emphasize the hazards that a rigid application of the International Code of Zoological Nomenclature would bring, potentially adding confusion and damaging modern taxonomic usage. The solution of this problem requires, in addition to formal rulings of the commission, a consensus among radiolarian specialists, and for this reason we do not in this paper propose any formal revisions to radiolarian taxonomy: Instead, we only comment on differences between modern usage and the actual specimens.

One surprising result is to have found internal structure in the type species of the genera *Cenosphaera* Ehrenberg 1854a and *Acanthosphaera* Ehrenberg 1862. These two genera have long been considered to have nothing inside the cortical shell, but *Cenosphaera plutonis* (pl. 30, figs. 1a–1d), the type species of *Cenosphaera*, apparently consists of three concentric shells, and consequently is consistent with the current definition of the genus *Thecosphaera* Haeckel 1882. The type species of *Acanthosphaera* is *Acanthosphaera haliphormis* Ehrenberg 1862 (pl. 42, figs. 1a–1c). The actual specimen of this species is so poorly preserved that the detailed structure of this specimen is unclear, but two concentric structures are likely to be present inside the test. This species was recovered from the Davisstraße, and it is most likely a specimen of the modern taxon *Actinomma boreale* Cleve or a related species. These morphological characters of *Acs. haliphormis* are thus the same as the genus *Actinomma* Haeckel 1860a. If the Code's rules were rigidly applied, all current *Thecosphaera* species would have to be moved to the 'true' *Cenosphaera* and the current *Cenosphaera* would be moved to the other genus. In this case, more than 58 *Thecosphaera* species would move to *Cenosphaera* and more than 170 *Cenosphaera* species have to be transferred to the other genus. This change also would make many synonyms between *Cenosphaera* and *Thecosphaera*, and subsequently a rigid application of ICZN 2000 is not practical procedure: it would create, rather than help settle taxonomic confusion. Similar problems will arise in *Acanthosphaera*, *Astromma* (type species: *Astromma entomocora* Ehrenberg 1854b. See pl. 29, figs. 1a–1c in our paper), *Dictyophimus* (type species: *Dictyophimus crisiae* Ehrenberg 1854a. See pl. 35, figs. 1a–1d in our paper), *Lithocampe* (type species: *Lithocampe radiculata*. See pl. 12, figs. 7a–7c), and *Pterocanium* (type species: *Pterocanium aculeatum* Ehrenberg 1844c. See pl. 29, figs. 3a–4d in our paper).

A rigid application of ICZN 2000 also would produce unfruitful confusion for many other well known species names. Ehrenberg (1873a, 1873b) described and illustrated species which now belong to the subfamily Artiscinae. *Ommatospyris laevis* Ehrenberg 1873a (pl. 52, figs. 4a–4c), *Ommatospyris setosa* Ehrenberg 1873a (pl. 52, figs. 5a–5c), *Ommatospyris penicillata* Ehrenberg 1873a (pl. 52, figs. 6a–6c) and *Ommatospyris profunda* Ehrenberg 1873a (pl. 52, figs. 7a–7c) are comparable to ontogenetic stages of a well-known species, *Didymocyrtis tetrathalamus tetrathalamus* (Haeckel 1887). Similar problems will happen with *Lit. radicula* and *Lithocampe siculum* Ehrenberg 1859 (pl. 13, figs. 1a–1c). *L. siculum* is morphologically similar to *Stichocorys peregrina* (Riedel 1953). *Sti. peregrina* has long been cited in numerous papers in the Deep Sea Drilling Project, Ocean Drilling Program and Integrated Ocean Drilling Program, and the replacement of the species name is not scientifically useful.

Our reexamination has largely succeeded in identifying the published specimens from the Ehrenberg Collection, which have potential to be used as lectotypes for Ehrenberg's species. For taxonomic stability, not all the discovered specimens are always appropriate to use as lectotypes. *Podocyrtis aegles* Ehrenberg 1854a (pl. 32, figs. 9a–9c) and *Rhopalastrum lagenosum* (Ehrenberg 1840) (pl. 24, figs. 10a–10b) for example have been damaged—they are cracked along the center of the test. Poorly preserved specimens are also inappropriate as lectotypes in the following species: *Dictyophimus crisiae* (pl. 35, figs. 1a–1d), *Haliomma hexagonum* Ehrenberg 1854a (pl. 36, figs. 2a–2d), *Acanthosphaera haliphormis* Ehrenberg 1862 (pl. 42, figs. 1a–1c), *Mazosphaera laevis* Ehrenberg 1873a (pl. 51, figs. 2a–2b), *Stylosphaera setosa* Ehrenberg 1873a (pl. 52, figs. 12a–12c), *Ceratospyris setosa* Ehrenberg 1873a (pl. 52, figs. 1a–1c), *Stylosphaera megadictya* Ehrenberg 1873a (pl. 53, figs. 3a–3d), *Ceratospyris aculeata* Ehrenberg 1873a (pl. 53, figs. 4a–4b) and *Eucyrtidium cassis* Ehrenberg 1873a (pl. 53, figs. 6a–6c). Several specimens are fixed at a difficult orientation to use as a standard specimen for classification: *Carpocanium arachnodiscus* Ehrenberg 1862 (pl. 41, figs. 6a–6e) and *Halicalyptra hexathyris* Ehrenberg 1862 (pl. 43, figs. 6a–6g).

We tentatively conclude that formal taxonomic fixation of Ehrenberg's polycystine radiolarian names must be done carefully, and in a way so as not to bring scientifically unfruitful confusion. This will only be possible if for some taxa, taxonomic stability of common use be given priority over rigid application of ICZN 2000 rules.

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